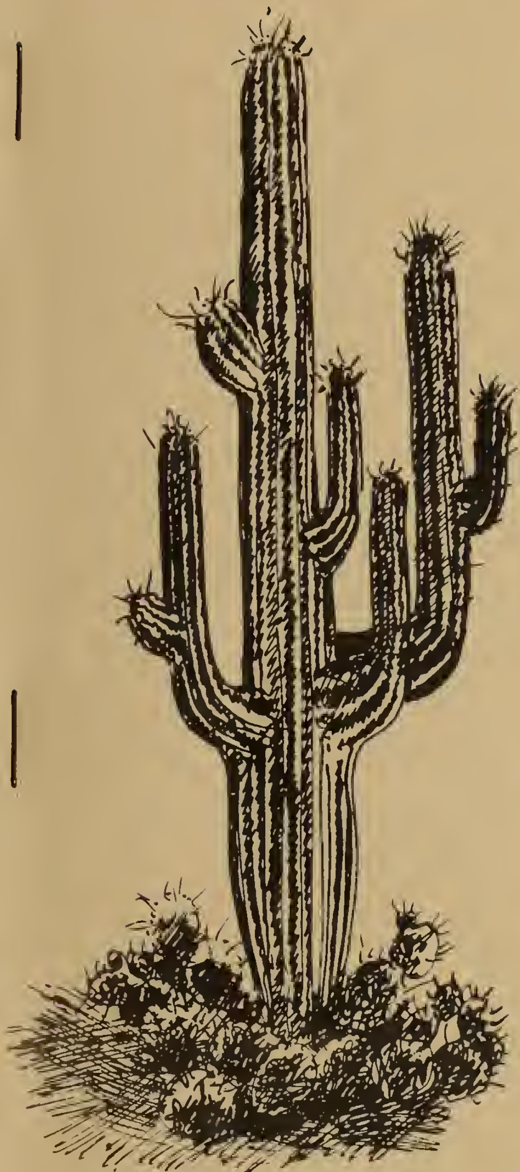

Cooperative National Park Resources Studies Unit

ARIZONA

TECHNICAL REPORT NO. 28

Smallmouth Bass and Ozark Bass in Buffalo National River

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COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
University of Arizona/Tucson - National Park Service

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UNIVERSITY OF ARIZONA
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May, 1989

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SMALLMOUTH BASS AND OZARK BASS

IN

BUFFALO NATIONAL RIVER

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INTRODUCTION

Description of the Study Area

The Buffalo River (Figure 1) is a tributary of the White River, in the Ozark Mountains of north central Arkansas; average width of the basin is 35.4 km, with a drainage area of 3,465 km^2. The river originates in the Boston Mountains of Newton County and flows for 238 km in an easterly direction through Searcy and Marion Counties. The eastern half of the basin dissects the Springfield Plateau and near the mouth the river cuts through the Salem Plateau (U.S. Army Corps of Engineers 1964). The Buffalo River enters the White River about 50 km downstream from Bull Shoals Dam and 18 km upstream from the mouth of the North Fork River. The lower 221 km of this river, along with 38,757 ha along the banks of the river, were designated as a National River in 1972 (Public Law 92-237).

Objectives of the Study

This study of Ozark bass and smallmouth bass was initiated to accomplish three objectives, namely: 1) to determine whether increased recreational use, 5,500 canoeists in 1963 vs 51,000 in 1981 (U.S. National Park Service, 1975, 1982) was having a negative impact on the principal sport fishes in the river; 2) to provide baseline data on habitat use and population characteristics of Ozark bass, a species described by Cashner and Suttkus (1977) but on which there was no previous published information; and 3) to determine how habitats used by smallmouth bass in Buffalo River compared to those occupied elsewhere.

This paper reports the findings from the research into these three areas. The report is intended to be of use to both the resource manager and the fisheries scientist.

Description of the Study Sites

Ozark bass and smallmouth bass were studied at 12 sites (Figure 2), 11 in the Buffalo River and 1 in a tributary called Calf Creek during 1980 and 1981. Each site consisted of a pool and the adjacent upstream riffle. Generally, study sites were sampled once each in fall, winter, and spring, and three times in summer.

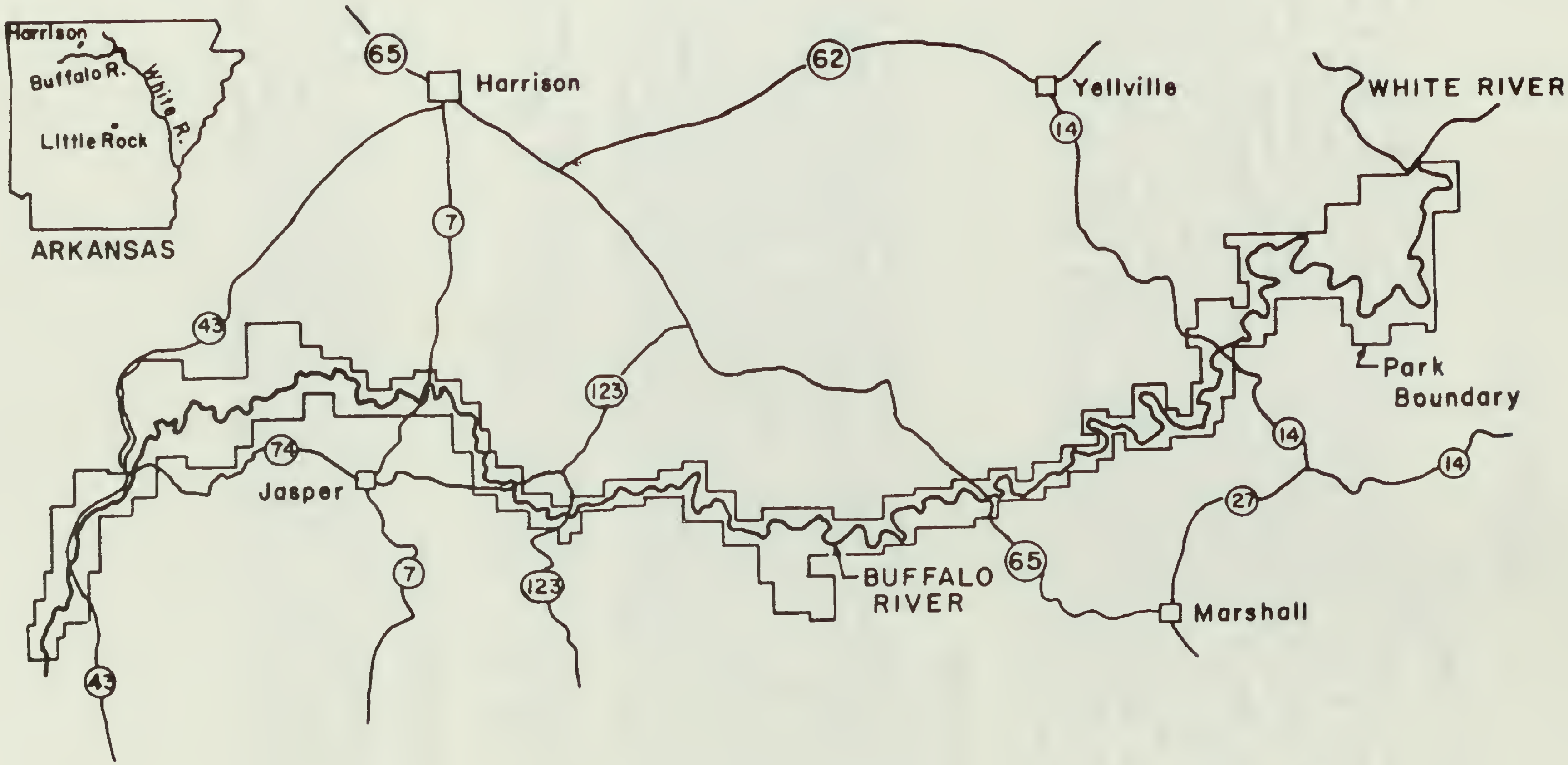

Figure 1. Buffalo National River, Arkansas.

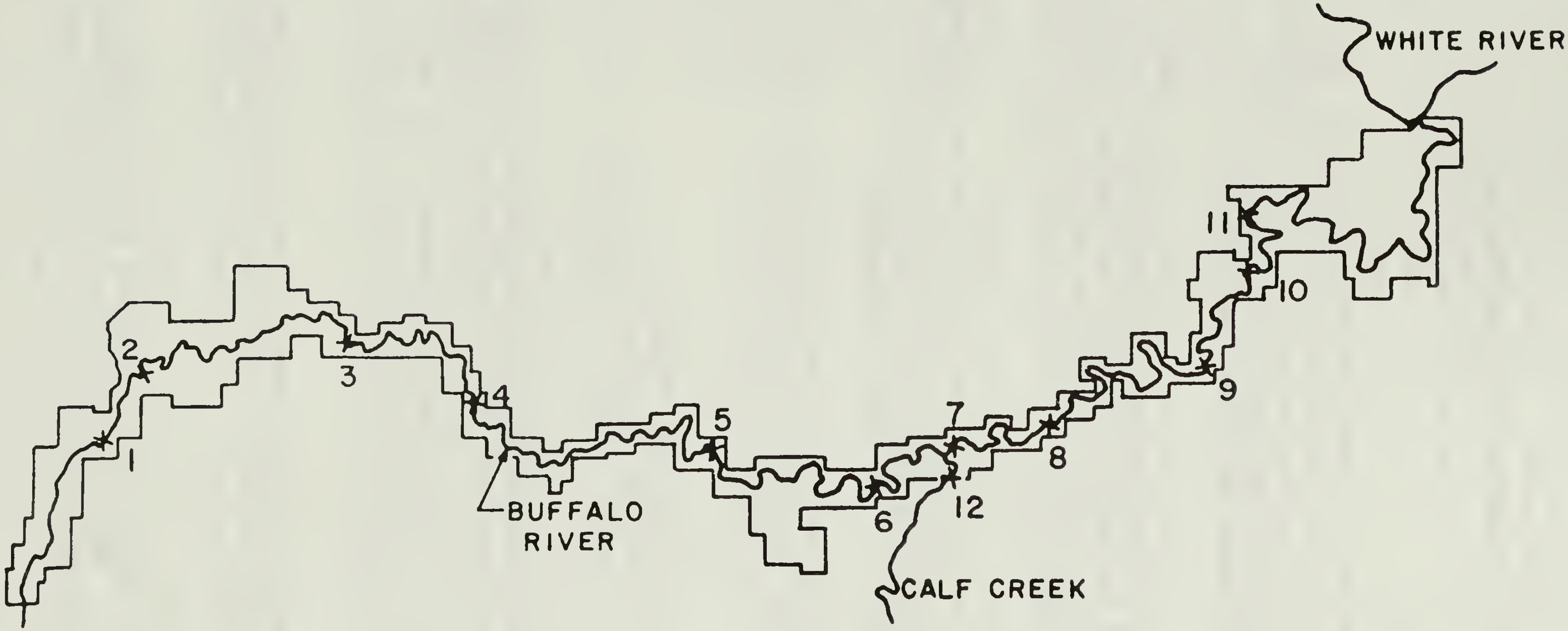

Figure 2. Sample site location map.

METHODS/RESULTS AND DISCUSSION

Ozark Bass Populations

Ozark bass were sampled with a boat-mounted, Coffelt VVP 15 electroshocking unit operated on DC pulse at 600 volts, 3-6 amps, pulse frequency of 80-100 cycles/second, and 40 to 50% pulse width. Ozark bass were weighed, measured (total length), and a few scales taken. Fish were returned to the river.

Population estimates for Ozark bass in Buffalo National River were made by using the depletion method described by Carle and Maughan (1980) and the maximum likelihood estimator of Carle and Strubb (1978). A unit of effort consisted of electroshocking the entire site. Two or three units of effort were used to make each population estimate.

Densities were determined by dividing population estimates by the total area of the site. Standing crop (per unit of area) 3 was determined by multiplying the population estimates by the mean weight and then dividing by the area of the site.

Coefficients of condition or condition factors were determined by season and by size class from the equation (Ricker 1975):

$$K = W \times 10^5 / L^3,$$

where K = Condition Factor
W = weight in grams
L = total length in millimeters.

Length at age was determined from scales removed from 3462 fish. The scales were removed from an area below the lateral line at the tip of the depressed pectoral fin. Scales were pressed onto acetate slides (Smith 1954) and were magnified 60X by a Bausch and Lomb microprojector. Counts and measurements of annuli were made along the anterior scale radius (Paragamian 1973). Mortality of fish was calculated by using a catch curve (Ricker 1975).

Seasonal populations varied within and between sites (Table 1). Mean densities (estimated number of Ozark bass per hectare) ranged in 1981 from a high of 45.7 in winter to a low of 22.3 in summer (Table 2).

The mean standing crop (estimated kilograms per hectare) reached 4 kg/ha in summer 1980 (Table 3), and then gradually declined with each subsequent season to a low of 2.4 in summer 1981. Annual mortality rate was 58% for Ozark bass (Table 4).

Table 1. Population estimates for Ozark bass in Buffalo River, Arkansas, from summer 1980 to summer 1981. Numbers in parentheses are the 95% confidence intervals for the estimates. Dashes indicate that no sample was taken. Letters at the site number give the chronological sequence in which the summer samples were taken.

Site	Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
1.a.	10 (10-13)	4 (4-7)	23 (21-29)	47 (43-55)	13 (11-21)
b.	24 (20-35)				13 (13-15)
c.	15 (14-20)				15 (14-20)
2.a.	27 (24-35)	27 (20-46)	32 (25-49)	16 (13-27)	49 (47-54)
b.	38 (27-64)				24 (22-30)
c.	42 (22-108)				5 (5-8)
3.a.	9 (9-11)	50 (22-158)	14 (14-16)	8 (6-21)	2 (2-3)
b.	32 (29-39)				10 (6-39)
c.	6 (6-7)				3 (3-6)
4.a.	9 (9-10)	9 (9-10)	20 (18-26)	2 (2-4)	3 (3-4)
b.	33 (26-49)				17 (13-32)
c.	30 (22-51)				2 (2-3)
5.a.	- -	22 (18-34)	3 (3-7)	25 (19-42)	48 (23-135)
b.	68 (58-83)				22 (19-31)
c.	55 (47-68)				36 (30-49)
6.a.	83 (152-214)	107 (69-164)	246 (105-487)	91 (51-169)	73 (52-107)
b.	98 (89-109)				37 (35-42)
c.	65 (60-73)				65 (49-91)
7.a.	27 (18-55)	59 (45-83)	40 (28-68)	45 (41-53)	17 (17-18)
b.	13 (12-18)				42 (30-68)
c.	- -				26 (24-32)
8.a.	32 (29-39)	74 (41-147)	78 (31-243)	56 (31-121)	16 (14-24)
b.	131 (77-212)				59 (47-79)
c.	42 (38-50)				22 (21-26)
9.a.	35 (34-39)	- -	423 (74-2133)	55 (27-142)	48 (40-63)
b.	- -				30 (29-34)
c.	39 (36-46)				23 (23-27)
10 a.	16 (15-21)	- -	10 (8-20)	49 (31-91)	8 (8-11)
b.	44 (36-59)				29 (22-47)
c.	10 (10-11)				12 (11-17)
11.a.	- -	34 (30-44)	14 (12-22)	36 (26-60)	71 (49-109)
b.	66 (44-110)				61 (49-80)
c.	54 (50-61)				39 (34-49)
12.a.	7 (5-23)	- -	3 (3-4)	7 (7-10)	0 -
b.	0 -				0 -

Table 2. Seasonal densities (No./ha) of Ozark bass in Buffalo River, Arkansas for each season.

	Season				
Site Number	Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
1	30	7	43	87	25
2	123	93	110	55	90
3	17	53	15	8	5
4	26	10	22	2	8
5	87	31	4	35	50
6	71	66	150	56	36
7	11	33	22	25	16
8	36	39	41	29	17
9	10	-	115	15	9
10	6	-	3	13	4
11	8	5	2	5	8
12	27	-	23	54	0
Mean	38	37	46	32	22

Table 3. Seasonal standing crops (kg/ha) of Ozark bass in Buffalo River, Arkansas.

Site Number	Season Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
1	3.8	0.9	5.5	11.2	3.0
2	12.6	4.9	2.5	5.9	11.7
3	1.6	5.4	0.8	1.2	0.5
4	2.9	0.7	0.9	0.5	0.8
5	11.0	3.0	0.1	4.1	4.8
6	7.9	7.2	12.1	3.5	3.2
7	1.3	3.8	0.9	3.0	1.4
8	3.0	2.9	1.3	1.7	1.6
9	1.2	-	12.7	1.6	0.8
10	0.6	-	0.4	1.8	0.4
11	0.8	0.4	0.1	0.3	0.5
12	0.9	-	1.5	3.1	0.0
Mean	4.0	3.3	3.2	3.1	2.4

Table 4. Instantaneous mortality rates, Z, annual survival rate, S, and annual mortality rates, A. Computed by the catch curve method from electroshocking data for Ozark bass* in various river sections and sites on Buffalo River, Arkansas.

River location	Z	S	A
Overall	0.87	0.42	0.58
Upper river	0.60	0.55	0.45
Middle river	0.90	0.41	0.59
Lower river	1.14	0.32	0.68
Site 1	0.74	0.48	0.52
Site 2	0.39	0.68	0.32
Site 3	0.67	0.51	0.49
Site 4	0.88	0.41	0.59
Site 5	0.74	0.48	0.52
Site 6	0.84	0.43	0.57
Site 7	1.28	0.28	0.72
Site 8	0.98	0.38	0.62
Site 9	1.07	0.34	0.66
Site 10	1.15	0.32	0.68
Site 11	1.11	0.33	0.67

* Based on ages 5-8.

The K values for Ozark bass were highest in summer, lowest in winter, and intermediate in spring and fall (Table 5). Condition factors did not increase with length or size of fish (Table 5). The K of fish 51-100 mm long was higher than that of any other group during both summers, but was lower than that of any other group in winter. The K in fish of each size class was lower in summer 1981 than in summer 1980.

Length at age in all age classes of Ozark bass was greater in summer 1981 (Table 6) than in summer 1980. Length at age varied among and between years, sites, and age classes (Tables 7-8). During summer and fall 1980, and spring 1981, about half of all Ozark bass captured were longer than 171 mm (Table 9); the size at when anglers began to keep them. A smaller percentage of fish exceeded this length during winter (39%) and summer 1981 (42%). No previous growth data have been published on Ozark bass, but comparison of our data on Ozark bass with data on rock bass shows Ozark bass were larger at age 1 but smaller at other ages than rock bass (Carlander 1977). Condition factors for Ozark bass, during summer 1981 (1.74-2.16) were within the range of condition factors cited as average by Carlander (1977) for the closely related rock bass, and size at age did not differ greatly between the two years.

Changes in mean density, standing crop, and K factor within and between sites and seasons was probably primarily due to movement of fish, but mortality was also involved. Although overall mortality rates for Buffalo River fish in this study were similar to those previously reported for fished (35-75%) and unfished rock bass (56-79%) populations, there was a 41% reduction in mean density and lower standing crops and K factors of Ozark bass in summer 1981 compared to summer 1980.

Differential size mortality (such as caused by angling) did not appear to have occurred since each size class made up a similar percentage of the population in summer 1980 and 1981. These changes were correlated with drought conditions in both these years(mean flow 1939-1981 28.8 m^3/sec, 12.4m^3/sec in 1980, and 15.1 m^3/sec in 1981).

Smallmouth Bass Populations

Methods used to characterize populations of smallmouth bass were the same as those used to characterize populations of Ozark bass. Population size generally varied within sites, between sites, and between seasons (Table 10). By the end of summer 1981, populations at eight sites (Nos. 1, 2, 3, 4, 5, 8, 9, and 10) were smaller than they were at the end of summer 1980; no sites had populations that were larger.

Densities of smallmouth bass fluctuated from 46.8 bass/ha during the fall to 11.8 bass/ha during the summer of 1981 (Table 11). A wide range of densities was encountered between sites during each

Table 5. Condition factors, K, by size and season for Ozark bass in Buffalo River, Arkansas. Numbers in parentheses represent the 95% confidence intervals for the mean.

	SEASON				
Total Length (mm)	Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
<51	- -	1.46 N=2 (0.06-2.86)	2.05 N=1 -	2.37 N=9 (1.77-2.97)	3.08 N=5 (0.92-5.24)
51-100	3.47 N=118 (3.11-3.83)	2.05 N=48 (1.81-2.29)	1.69 N=125 (1.61-1.77)	1.96 N=71 (1.86-2.06)	2.10 N=134 (1.94-2.26)
101-150	2.07 N=235 (1.95-2.19)	1.95 N=63 (1.73-2.17)	1.64 N=60 (1.58-1.70)	1.79 N=47 (1.71-1.87)	1.85 N=251 (1.75-1.95)
151-200	1.96 N=499 (1.94-1.98)	1.92 N=113 (1.84-2.00)	1.79 N=96 (1.77-1.81)	1.91 N=103 (1.87-1.95)	1.86 N=222 (1.82-1.90)
201-250	1.92 N=226 (1.88-1.96)	1.92 N=57 (1.84-2.00)	1.83 N=56 (1.73-1.93)	1.94 N=66 (1.86-2.02)	1.89 N=165 (1.87-1.91)
251-300	1.98 N=12 (1.78-2.18)	1.75 N=4 (1.02-2.48)	2.07 N=2 (0.00-4.23)	2.00 N=4 (1.71-2.29)	1.84 N=11 (1.51-2.17)

Table 6. Total length of Ozark bass of different ages, calculated from seasonal catch data in Buffalo River, Arkansas.

	Mean calculated total length (mm) at each annulus								
Season	No.	I	II	III	IV	V	VI	VII	VIII
Summer '80	1090	-	90.4	117.1	148.6	178.6	209.7	228.2	256.4
Fall '80	287	-	107.2	128.9	157.4	182.7	209.8	243.6	-
Winter '80	340	59.4	94.7	138.4	171.5	194.7	211.4	-	-
Spring '81	300	53.4	93.5	138.0	170.1	182.9	206.4	-	-
Summer '81	788	51.4	91.7	135.9	172.2	197.7	224.0	231.0	-

Table 7. Size at age of Ozark bass as determined from fish caught during the summer of 1980, at 12 sites in Buffalo River, Arkansas. Sample size is in parentheses.

	Mean calculated total length (mm) at each annulus						
Site	II	III	IV	V	VI	VII	VIII
1	96.3 (35)	122.0 (33)	153.0 (24)	187.4 (9)	222.4 (4)	238.6 (1)	254.4 (1)
2	89.2 (58)	114.4 (54)	152.5 (38)	184.4 (14)	217.7 (7)	-	-
3	88.8 (38)	118.9 (28)	151.9 (20)	182.1 (8)	209.7 (3)	-	-
4	89.9 (49)	119.0 (44)	153.3 (37)	189.8 (16)	215.4 (3)	-	-
5	91.6 (106)	120.9 (101)	154.3 (66)	185.3 (30)	213.4 (8)	-	-
6	89.5 (200)	111.0 (186)	142.1 (114)	171.6 (66)	210.9 (24)	246.8 (1)	258.4 (1)
7	89.3 (26)	120.0 (21)	152.5 (17)	192.4 (7)	220.7 (2)	-	-
8	89.0 (105)	115.2 (82)	143.3 (66)	174.3 (33)	205.4 (4)	195.8 (1)	-
9	91.0 (59)	116.3 (55)	146.4 (50)	177.2 (29)	195.8 (8)	229.2 (2)	-
10	91.6 (44)	124.5 (37)	153.4 (28)	175.6 (15)	198.9 (2)	-	-
11	92.4 (82)	124.0 (64)	151.1 (59)	179.0 (25)	201.9 (7)	-	-
12	81.4 (5)	-	-	-	-	-	-

Table 8. Size at age of Ozark bass as determined from fish caught during the summer of 1980, at 12 sites in Buffalo River, Arkansas. Sample size is in parentheses.

	Mean calculated total length (mm) at each annulus						
Site	II	III	IV	V	VI	VII	VIII
1	43.1 (28)	84.7 (25)	123.7 (21)	154.9 (14)	184.4 (10)	208.5 (2)	- -
2	50.1 (57)	89.0 (51)	134.2 (40)	171.1 (33)	196.5 (10)	219.4 (3)	- -
3	50.3 (9)	88.4 (9)	119.0 (7)	152.3 (2)	202.2 (1)	- -	- -
4	50.2 (16)	88.6 (14)	137.8 (10)	173.0 (5)	- -	- -	- -
5	50.0 (60)	92.4 (48)	146.2 (21)	185.7 (14)	208.3 (3)	237.1 (2)	231.0 (1)
6	51.2 (68)	86.3 (61)	140.4 (27)	186.3 (23)	218.1 (4)	232.9 (1)	- -
7	50.0 (51)	93.0 (42)	138.3 (20)	176.9 (13)	206.8 (7)	- -	- -
8	49.6 (63)	90.0 (59)	132.5 (25)	166.0 (15)	198.2 (7)	225.1 (1)	- -
9	53.4 (49)	95.2 (48)	132.9 (24)	157.5 (15)	197.4 (3)	- -	- -
10	53.7 (25)	102.3 (24)	147.9 (12)	191.8 (7)	213.0 (2)	231.8 (1)	- -
11	53.9 (110)	95.4 (83)	137.7 (32)	167.9 (19)	185.0 (6)	- -	- -

Table 9. Cumulative length frequency distribution of Ozark bass populations.

Length (mm)	Summer '80 No.	Summer '80 %	Fall '80 No.	Fall '80 %	Winter '80 No.	Winter '80 %	Spring '81 No.	Spring '81 %	Summer '81 No.	Summer '81 %
21-150	2	0.2	3	1.0	1	1.0	9	3.0	7	0.9
51-80	92	8.2	9	3.1	39	11.4	29	9.6	57	7.2
81-110	88	7.8	53	18.3	105	30.8	57	18.9	128	16.2
111-140	158	14.0	24	8.3	30	8.8	22	7.3	166	21.0
141-170	223	19.8	50	17.3	33	9.7	38	12.6	98	12.4
171-200	324	28.8	89	30.8	75	22.0	76	25.2	158	20.0
201-230	183	16.3	43	14.9	46	13.5	50	16.6	131	16.6
231-260	50	4.4	17	5.9	11	3.2	20	6.6	40	5.1
261+	6	0.5	1	0.3	1	0.3	0	0.0	6	0.8
	1126	100.0	289	99.9	341	100.0	301	99.8	791	100.2

Table 10. Population estimates for smallmouth bass in Buffalo River, Arkansas from summer 1980 through summer 1981. Numbers in parentheses are the 95% confidence intervals for the estimates. Dashes indicate that no sample was taken. Letters by the site number give the chronological sequence in which the summer samples were taken.

Site No.	Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
1.a.	27 (21-43)	40 (24-85)	43 (28-79)	25 (15-63)	9 (8-15)
b.	35 (31-44)	-	-	-	13 (13-15)
c.	29 (25-39)	-	-	-	9 (8-15)
2.a.	36 (29-51)	34 (31-41)	20 (18-26)	14 (9-40)	27 (20-46)
b.	55 (42-78)	-	-	-	20 (20-21)
c.	34 (31-41)	-	-	-	17 (17-19)
3.a.	6 (6-7)	41 (33-57)	27 (25-32)	6 (6-7)	-
b.	28 (28-30)	-	-	-	6 (5-14)
c.	19 (19-21)	-	-	-	3 (3-4)
4.a.	16 (16-18)	21 (19-28)	33 (26-49)	23 (18-38)	8 (8-10)
b.	23 (21-29)	-	-	-	10 (10-11)
c.	34 (26-53)	-	-	-	2 (2-4)
5.a.	-	14 (14-16)	7 (7-10)	3 (3-6)	0 -
b.	27 (22-40)	-	-	-	1 (1-5)
c.	9 (9-10)	-	-	-	7 (7-9)
6.a.	57 (26-162)	40 (30-62)	143 (92-208)	38 (31-53)	3 (3-3)
b.	46 (36-65)	-	-	-	3 (3-4)
c.	60 (40-99)	-	-	-	14 (7-65)
7.a.	23 (12-76)	112 (95-131)	110 (73-162)	48 (45-54)	5 (5-7)
b.	13 (12-18)	-	-	-	23 (21-29)
c.	-	-	-	-	8 (8-10)
8.a.	8 (8-9)	61 (53-74)	69 (23-295)	35 (28-50)	4 (4-5)
b.	59 (32-129)	-	-	-	5 (5-7)
c.	27 (26-30)	-	-	-	5 (5-8)
9.a.	38 (36-43)	-	273 (87-737)	110 (105-117)	1 (1-1)
b.	-	-	-	-	10 (9-16)
c.	158 (43-643)	-	-	-	0 -
10.a.	19 (14-36)	-	19 (18-23)	25 (14-71)	2 (2-4)
b.	27 (25-33)	-	-	-	11 (11-13)
c.	34 (27-50)	-	-	-	4 (4-8)
11.a.	-	189 (112-292)	87 (38-227)	193 (97-340)	19 (18-23)
b.	62 (41-106)	-	-	-	8 (6-21)
c.	75 (38-168)	-	-	-	42 (30-68)
12.a.	4 (4-5)	-	7 (7-7)	1 (1-2)	1 (1-1)
b.	3 (3-4)	-	-	-	3 (3-3)

Table 11. Seasonal densities (No./ha) of smallmouth bass in Buffalo River, Arkansas for each season.

	Season				
Site No.	Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
1	56.2	74.1	79.6	46.3	19.2
2	143.7	117.2	69.0	48.3	73.6
3	18.6	43.2	28.4	6.3	4.8
4	26.2	22.6	35.5	24.7	7.2
5	25.4	19.7	9.9	4.2	3.8
6	33.3	24.5	87.7	23.3	4.1
7	10.0	61.9	60.8	26.5	6.3
8	16.3	31.8	35.9	18.2	2.4
9	26.6	-	74.2	29.9	1.0
10	7.0	-	5.0	6.5	1.5
11	9.4	25.8	11.9	26.4	3.1
12	27.0	-	53.8	7.7	15.4
x	33.0	46.8	46.0	22.4	11.8

season. The mean standing crop of smallmouth bass was highest (5.8 kg/ha) in the summer of 1980 and lowest (1.9 kg/ha) in the summer of 1981. Standing crops varied widely among sites and seasons (Table 12).

The mean K value was highest (1.45) during the summer of 1980 and lowest (1.13) during the winter of the same year (Table 13). The coefficient of condition in the summer of 1981 was 1.28. Except for fish > 500 mm, condition factors generally tended to be lower for fish larger than 100 mm compared to those group during both summers, but was lower than that of any group in winter. The K fish of each size class was smaller than 100 mm (Table 14).

Sizes at age during summer 1981 were lower than those during summer 1980 (Table 15). During summer 1980, sizes at age varied among sites (Table 16). Sizes at age, until age 3, generally exceeded the North American average cited by Carlander (1977); they were near this average from ages 4-6 and above the average at ages 7-8.

During the summer of 1980, 36.7% of all smallmouth bass were larger than 230 mm but during the next summer only 28.4% exceeded this size (Table 17). During fall, winter and spring of 1980-81 the percentage of bass over 230 mm was 22.3, 21.3, and 19.0%, respectively. These data indicate that if smallmouth bass reach maturity at ages three or four, as has been reported for other waters (Carlander 1977), then up to 36.4% of the smallmouth bass population were capable of spawning in 1980.

The overall annual mortality rate for smallmouth bass in this study was 42% (Table 18). The upper river sites had the lowest annual mortality (39%) and the middle river had the highest (53%). Mortality varied widely among sites.

The within and between site and between season fluctuations observed in population parameters of smallmouth bass were probably related to movement of smallmouth bass between sites. The work of previous authors (Larimore 1952; Gerking 1953; Fajen 1962; Munther 1970) has established that movement occurs within streams.

Mortality either from angling, sampling stress, or natural causes could have also played a part in changing population levels. However, if mortality were the only contributing factor, the population estimates would be expected to decline with each subsequent sample. Steadily declining populations occurred only at sites 5 and 12 in 1980 and at sites 2,3, and 4 in 1981. In addition, the most accessible sites (1,2,7, and 8) and the ones receiving the most human use (sites 2,9,10, and 11), were not the ones with the greatest seasonal decline in populations, nor were larger fish impacted more than smaller fish. Mortality was, however, important because there was a 64.6% decrease in density from summer 1980 to summer 1981.

Table 12. Seasonal standing crops (kg/ha) of smallmouth bass in Buffalo River, Arkansas.

	Season				
Site No.	Summer '80	Fall '80	Winter '80	Spring '81	Summer '81
1	9.8	10.5	6.6	3.7	4.8
2	23.2	8.2	1.2	14.4	10.2
3	4.1	3.4	4.4	1.8	0.2
4	4.2	2.8	2.5	7.3	2.8
5	4.6	1.6	0.2	0.7	0.4
6	6.5	2.1	10.1	0.7	0.3
7	1.4	3.6	2.4	1.5	0.6
8	3.0	1.6	6.1	1.2	0.2
9	6.4	-	19.0	5.9	0.4
10	1.6	-	1.4	0.3	0.1
11	1.2	1.9	0.3	1.3	0.3
12	3.0	-	5.7	0.6	2.6
x	5.7	3.9	5.0	3.3	1.9

Table 13. Seasonal coefficients of condition, K, for smallmouth Bass in Buffalo River, Arkansas.

Season	Sample Size	K	95% Confidence Interval
Summer 1980	709	1.45	1.39-1.51
Fall 1980	542	1.33	1.27-1.39
Winter 1980	440	1.13	1.11-1.15
Spring 1981	372	1.19	1.17-1.21
Summer 1981	275	1.28	1.22-1.34

Table 14. Condition factors, K, by size and season for smallmouth bass in Buffalo River, Arkansas. Numbers in parentheses represent the 95% confidence intervals for the mean.

	Season				
Total Length (mm)	Summer 1980	Fall '80	Winter '80	Spring '81	Summer '81
51-100	2.17 N=115 (1.89-2.45)	1.98 N=94 (1.76-2.20)	1.22 N=99 (1.14-1.30)	1.30 N=94 (1.22-1.38)	1.30 N =36 (1.10-1.50)
101-150	1.53 N=100 (1.40-1.66)	1.13 N=179 (1.07-1.19)	1.02 N=129 (0.98-1.06)	1.09 N=118 (1.05-1.13)	1.12 N= 64 (1.06-1.11)
151-200	1.35 N=103 (1.27-1.43)	1.22 N=106 (1.16-1.28)	1.08 N=93 (1.06-1.10)	1.15 N=66 (1.09-1.21)	1.14 N=42 (1.08-1.20)
201-250	1.24 N=155 (1.20-1.28)	1.24 N=69 (1.18-1.30)	1/20 N=35 (1.14-1.26)	1.15 N=32 (1.07-1.23)	1.19 N=59 (1.13.1.25)
251-300	1.23 N=121 (1.20-1.26)	1.24 N=55 (1.20-1.28)	1.14 N=39 (1.10-1.18)	1.23 N=25 (1.17-1.29)	1.24 N=30 (1.20-1.28)
301-350	1.24 N=69 (1.19-1.29)	1.29 N=32 (1.21-1.37)	1.28 N=21 (1.22-1.34)	1.29 N=17 (1.23-1.35)	1.18 N=16 (1.01-1.35)
351-400	(1.24 N=22 (1.20-1.28)	1.19 N=3 (0.89-1.49)	1.30 N=13 (1.17-1.43)	1.39 N=11 (1.30-1.48)	1.35 N=4 (1.25-1.45)
401-450	1.30 N=15 (1.23-1.37)	1.40 N=1 -	1.13 N=5 (1.06-1.56)	1.44 N=7 (1.24-1.64)	1.31 N=8 (1.22-1.40)
451-500	1.27 N=8 (1.18-1.36)	1.38 N=2 (0.87-1.89)	1.37 N=6 (1.29-1.95)	1.30 N=2 (0.79-1.81)	1.35 N=1 -

The high K values calculated for bass less than 100 mm TL during summer 1980 and fall were due to sampling error in measuring the weight of small bass. The inaccuracies were corrected by the use of a scale that was more accurate for smaller fish during the remaining three seasons.

Table 15. Size at age of smallmouth bass as calculated from seasonal catch data in Buffalo River, Arkansas. Sample size is in parentheses.

	Mean calculated total length (mm) at each annulus							
Season	I	II	III	IV	V	VI	VII	VIII
Summer '80	125.5 (472)	178.6 (374)	229.0 (237)	275.2 (99)	328.2 (41)	360.8 (18)	407.1 (7)	449.9 (1)
Fall '80	130.1 (271)	179.2 (188)	228.7 (97)	269.1 (35)	316.6 (5)	376.8 (3)	413.0 (3)	-
Winter '80	100.5 (210)	155.0 (140)	217.7 (75)	271.9 (31)	343.4 (8)	394.1 (2)	423.6 (3)	445.9 (3)
Spring '81	99.4 (187)	159.1 (120)	214.0 (68)	273.3 (38)	317.5 (15)	383.6 (6)	424.4 (1)	-
Summer '81	95.0 (174)	150.9 (108)	201.0 (79)	237.8 (37)	295.3 (23)	355.6 (6)	384.7 (1)	406.7 (1)

Table 16. Size at age of smallmouth bass as determined from fish caught during the summer of 1980 at 12 sites in Buffalo River, Arkansas. Sample size is in parentheses. North American (N.A.) Average from Coble, 1975.

	Mean calculated total length (mm) at each annulus							
Site No.	I	II	III	IV	V	VI	VII	VIII
1	128	174	222	246	317	340	382	-
	(59)	(50)	(32)	(11)	(3)	(1)	(1)	-
2	120	164	218	292	344	370	-	-
	(63)	(46)	(21)	(6)	(5)	(2)	-	-
3	124	174	212	262	324	378	421	-
	(39)	(39)	(29)	(14)	(5)	(1)	(1)	-
4	118	159	207	240	300	362	430	-
	(44)	(34)	(20)	(6)	(3)	(2)	(2)	-
5	131	195	260	-	-	-	-	-
	(22)	(15)	(12)	-	-	-	-	-
6	129	186	238	286	308	343	410	450
	(51)	(40)	(23)	(10)	(5)	(2)	(1)	(1)
7	117	180	219	264	309	363	-	-
	(18)	(10)	(2)	(1)	(1)	(1)	-	-
8	119	175	231	268	302	365	409	436
	(34)	(28)	(16)	(9)	(2)	(2)	(2)	(1)
9	131	191	242	282	322	374	-	-
	(51)	(43)	(34)	(17)	(5)	(3)	-	-
10	132	193	240	292	342	356	385	-
	(41)	(31)	(24)	(17)	(8)	(3)	(2)	-
11	128	181	225	268	318	-	-	-
	(41)	(34)	(24)	(8)	(3)	-	-	-
12	121	179	-	-	-	-	-	-

Table 17. Cumulative length frequency distribution of smallmouth bass populations in Buffalo River, Arkansas.

Length (mm)	Summer '80 No.	Summer '80 %	Fall '80 No.	Fall '80 %	Winter '80 No.	Winter '80 %	Spring '81 No.	Spring '81 %	Summer '81 No.	Summer '81 %
< 80	124	15.6	18	3.3	20	4.5	19	5.1	42	15.3
81-130	144	18.1	205	37.7	169	38.4	168	45.2	40	14.5
131-180	102	12.8	113	20.8	96	21.8	64	17.2	56	20.4
181-230	133	16.8	87	16.0	61	13.9	50	13.4	59	21.5
231-280	150	18.9	64	11.8	33	7.5	31	8.3	39	14.2
281-330	72	9.1	37	6.8	31	7.0	12	3.2	22	8.0
331-380	41	5.2	17	3.1	15	3.4	15	4.0	8	2.9
381+	28	3.5	3	0.6	15	3.4	13	3.5	9	3.3
	794	100.0	544	100.1	440	99.9	372	99.9	275	100.1

Table 18. Instantaneous mortality rates, Z, animal survival rate S, and annual mortality rates, A. Computed by the catch curve method from electroshocking data for smallmouth bass in various river sections and sites on Buffalo River, Arkansas.

River location	Z	S	A
Overall	0.55	0.58	0.42
Upper river	0.49	0.61	0.39
Middle river	0.76	0.47	0.53
Lower river	0.52	0.59	0.41
Site 1	0.51	0.60	0.40
Site 2	0.63	0.53	0.47
Site 3	0.54	0.58	0.42
Site 4	1.55	0.21	0.79
Site 5	0.49	0.61	0.39
Site 6	0.63	0.53	0.47
Site 7	1.64	0.19	0.81
Site 8	0.60	0.55	0.45
Site 9	0.42	0.66	0.34
Site 10	0.42	0.66	0.34
Site 11	0.64	0.53	0.47

The annual mortality rate (42%) calculated during this study was higher than the one calculated (36%) by Kilambi et al. (1977) but lower than those (43-66%) reported by Coble (1975).

The range of densities encountered during this study, 1.0 to 143.7 bass/ha, were consistent with ranges that have been reported in Missouri (Fajen 1972) for Huzzah Creek (58 bass/ha) and Courtois Creek (56 bass/ha) and by Brown (1960) for several streams in Ohio (16, 26, 29, and 87 bass/ha, respectively). The ranges of seasonal mean densities (11.8 to 46.8 bass/ha) was lower than the 118 and 132 bass/ha that Paragamian (1973) found in either the Plover River or the Red Cedar River in Wisconsin, and were much lower than the densities (11 to 1,772 bass/ha) reported for the Maquokata River, Iowa (Paragamian 1979). Overall, the Buffalo River did not appear to support as high a standing crop as did some other smallmouth bass streams.

Seasonal values of K ranged from 1.13 to 1.45, but were similar to those obtained for populations on other streams and rivers (Paragamian 1979; Ackerman 1974; Reynolds 1965). K Values were generally inversely related to population densities. Condition factor was positively correlated with total length in summer 1981, which is in agreement with data reported by Bennett (1937) and Latta (1963) for fish from other streams. There was also a linear relationship ($r = 0.66$) during 1981 between K and density. This relationship is described by:

$$K = 1.13 + 0.006\ N,$$

where N = smallmouth bass density in No./ha.

The data indicate that bass in the smaller (one-and two-year-old fish) length classes were more numerous and had lower condition than fish from other length classes. The lower K values for smaller bass in 1981 suggest that the food base may not have been sufficient to support this segment of the population.

Lengths at age were higher during summer and fall 1980 than during winter, spring, and summer 1981. Movement of slower growing bass out of tributaries and into the river during colder weather, and their retention in the main river during the low flow of summer 1981, could explain these results.

Excepting the length attained in the first year, which appeared to be exceptional, and that of the fourth year, which was slightly lower than average, the lengths attained by each age group seemed consistent with those of smallmouth bass in Ozark streams in Missouri (Fajen 1972, Funk 1975) and Oklahoma (Orth et al. 1983). However, compared to lengths reported by Reynolds (1965) and Paragamian (1973) for fish from rivers in Iowa and Wisconsin, respectively, Buffalo River smallmouth bass were smaller at age.

Overall, however, Buffalo River smallmouth bass were very similar in size at age to the North American average (Coble 1975). A comparison of length at age of smallmouth bass from Buffalo River during 1975-1976 (Kilambi et al. 1977) with that during 1980-1981, showed higher values for age III+ bass and young-of-the-year; but lower ones for II bass.

Ozark Bass Habitat Use

During each season except summer 1980, capture locations of Ozark bass were marked with a plastic or styrofoam float attached to a lead weight. Water depth and velocity and substrate type were later determined at each capture location. Velocity was measured with a Teledyne Gurley Current Meter (Model 622) at 0.6 of the total depth. Predominant substrate was categorized as silt, sand (< 1.6 mm diameter), pebble (1.6-12.7 mm), gravel 12.7-76.2 mm), cobble 76.2-203.2 mm), boulder (> 203.2 mm), and bedrock.

Water occupied by Ozark bass was shallow (mean depth, 0.8 m) in summer and only slightly deeper (mean depth, 1.1 m) in winter (Table 19). Slow currents were occupied during both winter and summer (Table 20). During winter, most Ozark bass occupied bedrock and boulder substrates. Boulder substrates were used almost exclusively in summer 1981 (Table 21).

Ozark bass occupied areas of relatively shallow water in summer and only slightly deeper water in winter. Waters occupied during both seasons had little current, and were over boulder substrates The data appear to conform well with habitats occupied by the closely related rock bass (*Ambloplites rupestris*), i.e., streams of medium size with gravel, cobble, boulder, bedrock, and vegetation substrates (Gerking 1945; Trautman 1957; Brown 1960; Jones 1970).

The occupation of areas with low velocity seems reasonable because of body shape, but the attraction to shallow water areas is harder to explain. Perhaps, shallow areas are important for foraging.

Smallmouth Bass Habitat Use

Methods used to determine habitat use by smallmouth bass were the same as those used for Ozark bass. Habitat availability was determined in summer 1980 by measuring water depth and velocity and classifying substrate types at 1-m intervals along transects perpendicular to the direction of flow. Transects were spaced at intervals of 20 to 70 m depending on the size of the site. We used the same methods and equipment to measure the availability of depths, velocities, and substrate particle sizes as we used to measure these habitat characteristics at fish capture locations.

Table 19. Frequency of occurrence and percentage of total captures of Ozark bass at various depth intervals during winter 1980 and summer 1981.

	Winter 1980		Summer 1981	
1981 Depth	No.	% of Total	No.	% of Total
(cm)				
25	2	2	9	2
26-50	2	2	93	19
51-75	26	23	139	28
76-100	28	25	133	27
100-125	18	16	83	17
126-150	21	19	30	6
151-175	15	13	6	1
176-200	0	0	1	<1
Total	112	100	494	100

Table 20. Frequency of occurrence and percentage of total captures of Ozark bass at different water velocities during winter 1980 and summer 1981.

	Winter 1980		Summer 1981	
Velocity	No.	% of Total	No.	% of Total
(cm/s)				
0	48	43	171	35
1-5	22	19	66	13
6-10	24	21	75	15
11-15	10	9	60	12
16-20	3	3	26	5
21-25	1	1	32	7
26-30	1	1	21	4
31-35	1	1	13	3
36-40	1	1	13	3
41-45	0	0	7	1
46-50	1	1	1	<1
<50	0	0	8	2
Total	112		493	

Table 21. Frequency of occurrence and percentage of total captures of Ozark bass over different substrate types during winter 1980 and summer 1981.

	Winter 1980		Summer 1981	
Substrate	No.	% of Total	No.	% of Total
Silt	12	11	29	6
Sand	2	2	14	3
Pebble	1	1	20	4
Gravel	8	7	40	8
Cobble	21	19	74	15
Boulder	29	26	163	33
Bedrock	34	30	128	26
Detritus	1	1	1	<1
Vegetation	3	3	25	5
Total	111		494	

Each measurement represented the average condition in a section of stream 1 meter wide and extending half the distance to the next transect, both upstream and downstream. The amount of area for each interval of depth, velocity, and substrate was then determined by summing the areas of the segments with the same interval (Orth et al. 1982). Area values for each depth, velocity and substrate interval were converted to a percentage of the sample area because of the large differences in size of sites. Gradients for each site were determined from topographic maps of the U.S. Geological Survey. Densities, standing crops, and coefficients of condition were correlated with habitat factors, by season, site, and size class.

Depths occupied by smallmouth bass varied only slightly by season (Table 22). Mean depths of locations occupied by fish were 0.8 m in summer, 0.9 m in fall, 1.0 m in winter, and 1.1 m in spring.

There were seasonal differences in the water velocities preferred by smallmouth bass (Table 23). During summer 1980, smallmouth bass generally occupied areas of the river without current; 65% of all captures were in areas where velocity was nil and 77% in areas where velocities were < 5 cm/s. Mean capture velocity in summer was lower in 1980 (4.0 cm/s) than in 1981 (11.9 cm/s), as was median velocity (0 vs. 7 cm/s). The fish occupied slightly faster waters in the fall of 1980 than in the summer of 1980 (4.7 cm/s vs. 4.0 cm/s), and still faster velocities (7.3 cm/s) in the winter of 1980-81. Mean velocities in which fish were collected were highest (20.5 cm/s) in spring of 1981.

During summer 1980, boulders composed the most common substrate at capture sites (Table 24); 45% of all smallmouth bass collected were taken over this substrate. Bedrock (37%) and cobble (29%) ranked next and detritus was the least used substrate (1%). Silt occurred at only 14% of all capture locations and at 66% of these locations, silt only lightly covered cobble, boulder, or bedrock. In fall, 60% of smallmouth bass were taken over bedrock, 43% over boulders, and 27% over cobble. The predominant substrate types occupied (bedrock, boulder and cobble) in winter remained identical to those occupied in the fall. In spring, boulders occurred at 53% of the capture sites and bedrock at 55% of the sites.

Habitat use patterns in summer 1981 (Table 24) differed from those in summer 1980. During summer 1981, the most common substrates used by smallmouth bass were cobble (accounting for 38% of all captures), bedrock (26%), and boulders (36%). The major difference between the two summers was that smallmouth bass used gravel, cobble, boulder, and bedrock more evenly in 1981 than in 1980. It was possible to establish habitat preference only during summer 1980, when habitat measurements were taken. Smallmouth bass preferred depths of 0.26 to 1.25 m (Table 25) and avoided water of depths less than 0.25 m or greater than 1.76 m.

Table 22. Seasonal frequency of occurrence and percentage of total captures of smallmouth bass at various depth intervals.

	Summer '80		Fall '80		Winter '80		Spring '80		Summer '81	
Depth	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
(m)										
0.00-0.25	15	2	3	8	1	<1	0	<1	2	1
0.26-0.50	143	19	42	11	9	5	5	3	27	16
0.51-0.75	241	32	98	26	28	15	25	15	44	25
0.76-1.00	160	21	114	30	61	33	30	18	48	28
1.01-1.25	116	15	73	20	40	21	51	31	30	17
1.26-1.50	66	9	32	9	29	16	28	17	15	9
1.51-1.75	17	2	10	3	9	5	20	12	5	3
1.76-2.00	2	<1	3	1	6	3	3	2	2	1
2.01-2.25	0	<1	0	<1	4	2	1	1	0	<1
2.26-2.50	0	<1	0	<1	0	<1	1	1	0	<1

Table 23. Seasonal frequency of occurrence and percentage of total captures of smallmouth bass at different water velocities.

	Summer '80		Fall '80		Winter '80		Spring '81		Summer '81	
Velocity	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
(cm/s)										
0	416	65	42	21	64	35	8	5	46	27
1-5	77	12	66	34	44	24	19	12	25	13
6-10	58	9	43	22	27	15	23	14	38	22
11-15	42	7	21	11	21	12	30	18	16	9
16-20	21	3	7	4	11	6	18	11	13	8
21-25	8	1	9	5	5	3	17	10	13	7
26-30	3	1	1	1	2	1	10	6	2	1
31-35	6	1	2	1	5	3	8	5	9	5
36-40	4	1	0	<1	2	1	14	9	2	2
41-45	2	1	2	1	0	<1	3	2	1	<1
46-50	2	<1	0	<1	1	1	3	2	5	3
51+	3	<1	3	1	1	<1	11	7	3	2
Mean Vel.	4.0 cm/s		4.7 cm/s		7.3 cm/s		20.5 cm/s		11.9 cm/s	

Table 24. Seasonal frequency of occurrence and percentage of total captures of smallmouth bass over various substrate types in Buffalo River, Arkansas.

	Summer '80		Fall '80		Winter '80		Spring '81		Summer '81	
Substrate	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
Silt	110	9	61	10	44	15	20	7	16	6
Sand	34	3	5	1	9	3	15	5	12	5
Pebble	44	4	7	1	3	1	16	6	7	3
Gravel	137	11	67	11	18	6	11	4	36	14
Cobble	223	18	102	16	47	16	30	11	65	25
Boulder	344	29	159	25	73	24	87	32	62	24
Bedrock	284	24	222	35	102	34	86	31	45	18
Detritus	11	1	4	1	0	0	8	3	4	1
Vegetation	17	1	1	<1	4	1	3	1	9	4

Table 25. X^2 comparisons of predicted (random occurrence based on habitat availability) numbers of smallmouth bass occupying each depth interval.

Depth	Numbers Actual	Expected
(m)		
< 0.25	15	164
0.26-0.75	384	286
0.76-1.25	276	183
1.26-1.75	83	92
> 1.76	2	35

They preferred currents of 0-0.9 cm/sec but inhabited water at velocities of 1.0-20 cm/s (Table 26). Smallmouth bass selected cobble, boulder, and bedrock; occupied silt, detritus, and vegetation in proportion to its abundance; and avoided pebble and gravel substrates (Table 27).

In general, our data showed habitat use patterns for Buffalo River smallmouth bass similar to those previously reported for Ozarkian streams by Orth et al. (1982). However, our data also showed differences in seasonal habitat use. In winter and spring, bass remained in relatively deep low velocity water over large-particle substrates. Fish may move into these areas in winter to obtain winter cover and in spring to be near spawning sites. In summer and fall, fish selected relatively shallow water areas, generally with little current and with large-particle substrates. One interpretation of these data is that in these seasons fish require shallow areas (perhaps for foraging).

Overlapping Resource Use

Habitat utilization data and population data presented in earlier sections were used to evaluate overlap between the two species. In general, smallmouth bass and Ozark bass occupied similar but subtly different winter and summer habitats in reference to depth, velocity and substrate (Tables 28,29,30). The mean depths occupied were almost identical but Ozark bass tended to occupy shallower areas in winter and areas of less current in summer than did smallmouth bass. Although the overlapping use of resources has been used as evidence of competition between species, there is little evidence in the population parameters to support the conclusion that competition is limiting populations.

One might alternately hypothesize that limited reproductive success as the result of flood flows during the spawning seasons

Table 26. X^2 comparisons of predicted (random occurrence based on habitat availability) numbers of smallmouth bass occupying each velocity interval in summer of 1980.

Velocity	Numbers Actual	Expected
(cm/s)		
0-0.9	416	363
1.0-10.0	135	156
11.0-20.0	63	73
> 21.0	28	50

Table 27. X^2 comparisons of predicted (random occurrence based on habitat availability) numbers of smallmouth bass occupying each substrate interval in summer of 1980.

Substrate	Numbers Actual	Expected
Silt	110	80
Sand	34	61
Pebble	44	116
Gravel	137	267
Cobble	223	83
Boulder	344	40
Bedrock	284	82
Detritus	11	10
Vegetation	17	21

or limited survival of y-o-y over summer low flow periods might hold populations below habitat carrying capacity. If populations were limited by physical factors, high resource overlap could occur without competition.

Food Habits

During summer 1981, we measured the total length of all fish collected, and used glass tubes, as described by Gilliland et al. (1982) to remove stomach contents. Stomach contents were preserved in formalin and later identified as fish, crayfish or insects. The total number of forage fish taken per 10 seine hauls was recorded as an indication of food availability at each site. Crayfish densities were estimated by counting the number of crayfish inside a 1-m^2 metal sampling frame, about 0.2 m high. The frame was worked into the substrate and all rocks and boulders within the frame were overturned or removed until all crayfish within the grid were collected. No attempt was made to estimate insect availability.

Fish were found in 72% of the stomachs of smallmouth bass 101-200 mm long. Insects were found in 28% of these stomachs, and crayfish in 13%. Sixty five percent of the stomachs of smallmouth bass 201-300 mm long contained fish, 50% held crayfish, and 10% contained insects. Seventy-two percent of the stomachs of fish larger than 300 mm contained crayfish, and 33% contained fish (Table 31).

Forty-nine percent of the stomachs of Ozark bass 51-100 mm long contained insects, and 36% contained crayfish (Table 31). Sixty-two percent of the stomachs of Ozark bass 101-150 mm contained crayfish and about 20% contained fish and insects. Eighty-five percent of the stomachs of Ozark bass longer than 150 mm contained crayfish.

Fishes identified from smallmouth bass stomachs represented five generation - *Etheostoma, Lepomis, Notropis, Campostoma,* and *Cottus;* the predominant aquatic insects in the diet were mayflies (Ephemeroptera). Fishes taken by Ozark bass were primarily *Notropis* but two orangethroat darters (*Etheostoma spectabile*) were found in the stomachs. Mayflies were the most common aquatic insect taken by Ozark bass, but Plecoptera, Tricoptera, Diptera, Coleoptera, and Odonata were also present. Nine percent of the insects found in the stomachs of Ozark bass longer than 151 mm were dobsonfly larvae (Megaloptera).

The density of forage fish -- as judged by the number caught per 10 seine hauls (Table 32) -- varied from site to site. Smallmouth bass and Ozark bass density and standing crop were both correlated positively with crayfish populations. Density

Table 28. Two way tests of seasonal differences in depths occupied by A) smallmouth bass, B) Ozark bass, and C) smallmouth bass and Ozark bass.

Seasons Compared	Chi Square Value	Degrees of Freedom	Probability (P)
	A) Smallmouth bass		
Summer 1980 - Fall 1980	27.53	7	$P < 0.005$
Summer 1980 - Winter 1980	91.00	8	$P < 0.005$
Summer 1980 - Spring 1981	115.83	9	$P < 0.005$
Summer 1980 - Summer 1981	9.49	7	$*P > 0.100$
Fall 1980 - Winter 1980	33.03	8	$P < 0.005$
Fall 1980 - Spring 1981	58.71	9	$P < 0.005$
Fall 1980 - Summer 1981	2.75	7	$*P > 0.900$
Winter 1980 - Spring 1981	20.69	9	$P < 0.025$
Winter 1980 - Summer 1981	27.05	8	$P < 0.005$
Spring 1981 - Summer 1981	46.83	9	$P < 0.005$
	B) Ozark Bass		
Winter 1980 - Summer 1981	74.23	7	$P < 0.005$
	C) Smallmouth bass and Ozark bass		
Summer 1981	10.68	8	$*P > 0.100$
Winter 1980	20.81	7	$P < 0.500$

Table 29. Two way tests of seasonal differences in velocities occupied by A) smallmouth bass, B) Ozark bass, and C) smallmouth bass and Ozark bass.

Seasons Compared	Chi Square Value	Degrees of Freedom	Probability (P)
	A) Smallmouth bass		
Summer 1980 - Fall 1980	129.7	11	$P < 0.005$
Summer 1980 - Winter 1980	55.5	11	$P < 0.005$
Summer 1980 - Spring 1981	278.5	11	$P < 0.005$
Summer 1980 - Summer 1981	111.7	11	$P < 0.005$
Fall 1980 - Winter 1980	21.2	11	$P < 0.005$
Fall 1980 - Spring 1981	94.6	11	$P < 0.005$
Fall 1980 - Summer 1981	33.6	11	$P < 0.005$
Winter 1980 - Spring 1981	90.1	11	$P < 0.005$
Winter 1980 - Summer 1981	20.0	11	$P < 0.005$
Spring 1981 - Summer 1981	56.9	11	$P < 0.005$
	B) Ozark Bass		
Winter 1980 - Summer 1981	24.3	11	$P < 0.025$
	C) Smallmouth bass and Ozark bass		
Summer 1981	26.2	11	$P < 0.010$
Winter 1980	9.1	11	*$P > 0.500$

* Not significant at 0.05

Table 30. Two way tests of seasonal differences in substrates occupied by A) smallmouth bass, B) Ozark bass, and C) smallmouth bass and Ozark bass.

Seasons Compared	Chi-Square Value	Degrees of Freedom	Probability (P)
	A) Smallmouth bass		
Summer 1980 - Fall 1980	48.5	8	$P < 0.005$
Summer 1980 - Winter 1980	35.1	8	$P < 0.005$
Summer 1980 - Spring 1981	41.1	8	$P < 0.005$
Summer 1980 - Summer 1981	24.1	8	$P < 0.005$
Fall 1980 - Winter 1980	23.7	8	$P < 0.005$
Fall 1980 - Spring 1981	65.8	8	$P < 0.005$
Fall 1980 - Summer 1981	69.3	8	$P < 0.005$
Winter 1980 - Spring 1981	34.5	8	$P < 0.005$
Winter 1980 - Summer 1981	50.0	8	$P < 0.005$
Spring 1981 - Summer 1981	51.1	8	$P < 0.005$
	B) Ozark Bass		
Winter 1980 - Summer 1981	14.5	8	*$P < 0.10$
	C) Smallmouth bass and Ozark bass		
Summer 1981	32.9	8	$P < 0.050$
Winter 1980	6.3	8	*$P < 0.500$

* Not significant at 0.05.

Table 31. Percent of stomachs of smallmouth bass and Ozark bass with food that contained different food items (Summer 1981) in Buffalo River, Arkansas.

Length Class	No. of Stomachs With Food	Food Items: Crayfish	Fish	Insects	Unknown
		Smallmouth bass			
< 100	46	5	15	8	78
101-200	68	13	72	28	4
201-300	62	50	64	9	2
> 300	18	72	33	-	-
		Ozark bass			
51-100	39	36	18	49	2
101-150	141	62	19	21	4
> 150	260	85	12	8	1

and standing crop of Ozark bass were also negatively correlated with forage fish availability (Table 33).

Aggus (1973) reported that smallmouth bass generally forage on fish during summer but rely on crayfish during winter. Kilambi et al. (1977) drew a similar conclusion for adult smallmouth bass from the Buffalo River. Our data show fish less than 300 mm feed mainly on fish but that smallmouth bass over 300 mm feed predominantly on crayfish.

Reproductive Success

Numbers of young-of-the-year of smallmouth and Ozark bass per 10 seine hauls and per hectare (from electroshocking) made in 1980 and 1981 were used as an index of reproduction.

The number of smallmouth fry per 10 seine hauls varied by both site and year (Table 34) and by collecting method (Table 35). Electroshocking samples showed a decline of 79% in mean density in young-of-the-year smallmouth bass from 1980 to 1981 (Table 35). This index of reproductive success corresponded with the 65% decrease in overall smallmouth bass density between the two summers. According to USGS (1981), the summers of 1980-81 had extremely low flows (average annual flows from 1939-1981, 28.8 mm^3/sec; 13.4 m^3/sec in 1980, and 15.1 m^3/sec in 1981). Poor reproduction and survival of fishes under these conditions seem probable. The apparent relationship between flow and smallmouth population size and reproductive success would seem to indicate a system controlled by summer low flow.

Table 32. Relative density of forage fish (August-September 1981), and crayfish (September 1981) at 12 study sites in Buffalo River, Arkansas.

	Forage Fish	Crayfish	
Site No.	No. of species	No./10 seine hauls	No./m^2
1	14	115	4
2	10	51	8
3	18	103	5
4	15	145	2
5	19	62	5
6	24	163	4
7	15	119	1
8	14	94	2
9	15	78	<1
10	17	198	1
11	18	170	2
12	12	83	15
Mean	16	118	4

Angler Harvest

A creel census was conducted during spring 1981 and the summers of 1980 and 1981 by National Park Service rangers. Rangers patrolling the river recorded the (1) number of anglers in the group, (2) sex of anglers, (3) residence, (4) length of time fishing, (5) number and species of fish caught, (6) estimated or measured length and weight of each smallmouth bass and Ozark bass in the creel, and (7) fishing methods used. Park personnel stationed at river access points obtained the same information from canoe parties.

Of the 343 anglers surveyed, 51% were from a county that borders the river or from one of the adjacent counties; 74% were from Arkansas and 88% were male. Forty-one percent of the anglers fished from canoes, 45% from johnboats, and 14% from the river bank. Higher johnboat use occurred on the lower river (57%), than on the middle river (38%) or the upper river (11%). Conversely, canoe anglers were more common on the upper river (78%) than on the middle (56%) or lower (26%) sections. Anglers on the Buffalo River caught fish at an overall rate of 0.47 fish/hr, which included 0.29 smallmouth bass/hr and 0.07 Ozark bass/hr. Smallmouth bass caught were 146-515 mm in total length (mean, 280 mm); 34% (Figure 3) were shorter than the 254 mm length limit imposed by the Arkansas Game and Fish Commission in 1983.

Table 33. Correlations between summer density (No./ha), standing crop (kg/ha), and condition factors of smallmouth bass and Ozark bass and relative densities of forage fish (No./10 seine hauls), crayfish (No./m^2), and aquatic invertebrate populations (No./8 samples) in Buffalo River, Arkansas.

Correlation pairs	Relationship	r
Smallmouth bass		
Density (N)/Crayfish (C)	$\ln N = 1.01 + 0.18\ C$	0.63
Density (N)/Aquatic invertebrates (I)	$N = 151.17 - 22.71 \ln I$	-0.68
Standing Crop (S)/Crayfish	$S = -0.91 + 0.93\ C$	0.70
Standing Crop (S)/Aquatic Invertebrates (I)	$S = 26.58 - 4.04 \ln I$	-0.76
Ozark bass		
Density (N)/Crayfish (C)	$\ln N = 1.81 + 0.29\ C$	0.68
Density (N)/Forage fish (F)	$N = 195.66 - 37.13 \ln F$	-0.60
Standing Crop (S)/Crayfish (C)	$S = -0.77 + 1.14\ C$	0.81
Standing Crop (S)/Forage fish (F)	$S = 25.02 - 4.85 \ln F$	-0.62
Standing Crop (S)/Aquatic invertebrates (I)	$S = 22.78 - 3.28 \ln I$	-0.62
Condition Factor(K)/Aquatic invertebrates (I)	$K = -187.58 + 0.45\ I$	0.80

Data on aquatic invertebrate densities from Geltz and Kenny (1982)

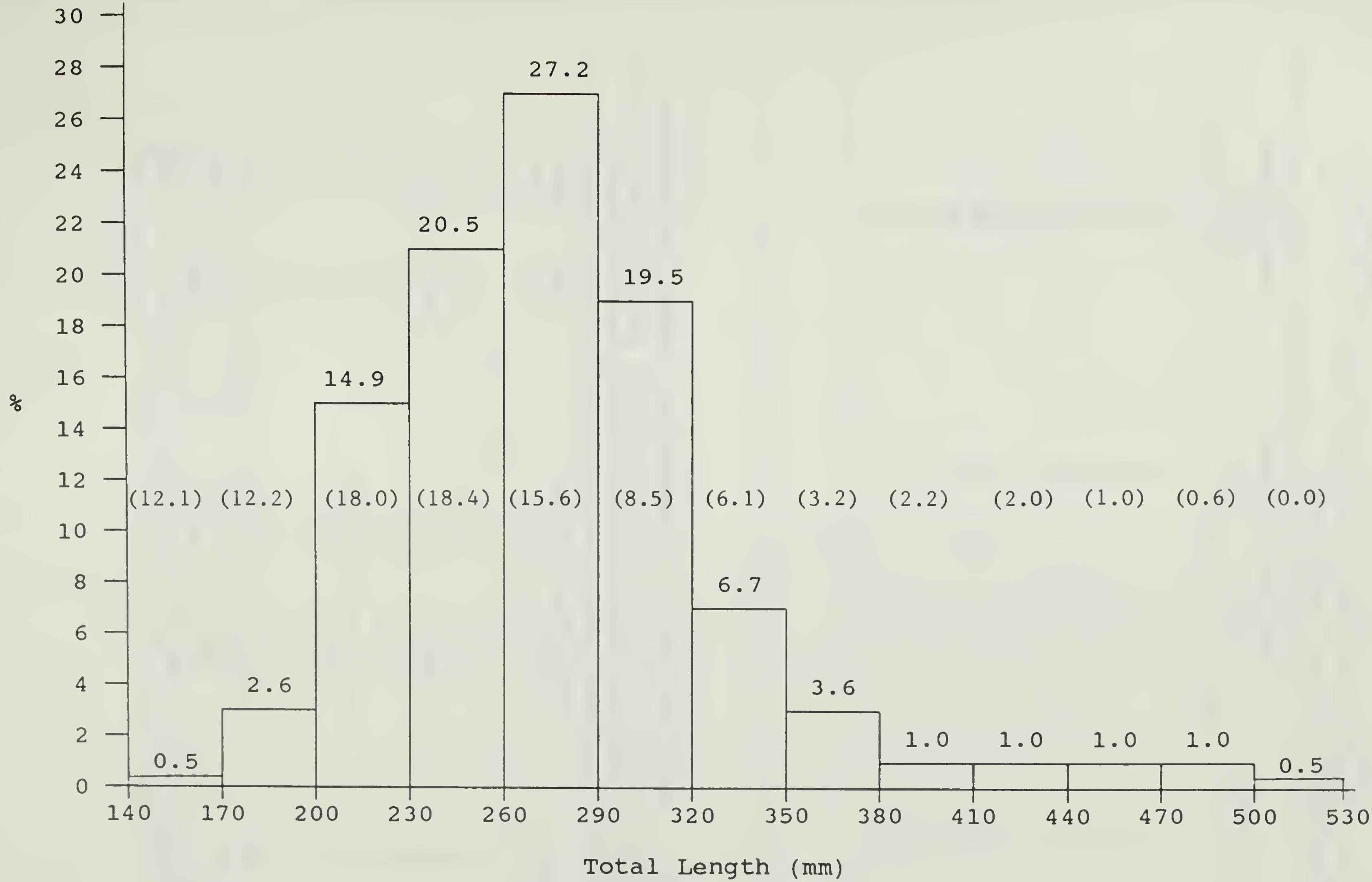

Figure 3. Length frequency distribution of the smallmouth bass caught by fishermen from Buffalo River, Arkansas. Data based on creel census results collected in 1980 and 1981. The percentage that each size class was represented in the natural population is given in parentheses.

Table 34. Density (number caught per 10 seine hauls) of smallmouth bass (1980-1981) and Ozark bass (1981) at 12 sites in Buffalo River, Arkansas.

Site No.	Smallmouth bass 1980	Smallmouth bass 1981	Ozark bass 1981
1	-	0	2
2	0	0	2
3	<0.5	6	0
4	3	3	0
5	2	8	3
6	1	19	47
7	1	0	0
8	-	0	0
9	0	7	0
10	14	1	1
11	5	1	1
12	0	1	1

Table 35. Relative density (estimated number per hectare) of smallmouth bass <80 mm long and Ozark bass <50 mm long at different sites, as indicated by summer electrofishing.

Site No.	Smallmouth bass 1980	Smallmouth bass 1981	Ozark bass 1980	Ozark bass 1981
1	3.7	0.0	0.0	0.6
2	14.0	2.4	0.0	0.0
3	4.2	0.3	0.0	0.0
4	3.5	0.7	0.0	0.0
5	5.4	0.9	0.0	0.5
6	3.7	0.6	0.4	0.4
7	1.1	2.2	0.0	0.2
8	1.7	0.0	0.0	0.0
9	1.8	0.0	0.0	0.0
10	0.7	0.5	0.0	0.0
11	1.2	0.5	0.0	0.1
12	0.0	0.0	0.0	0.0

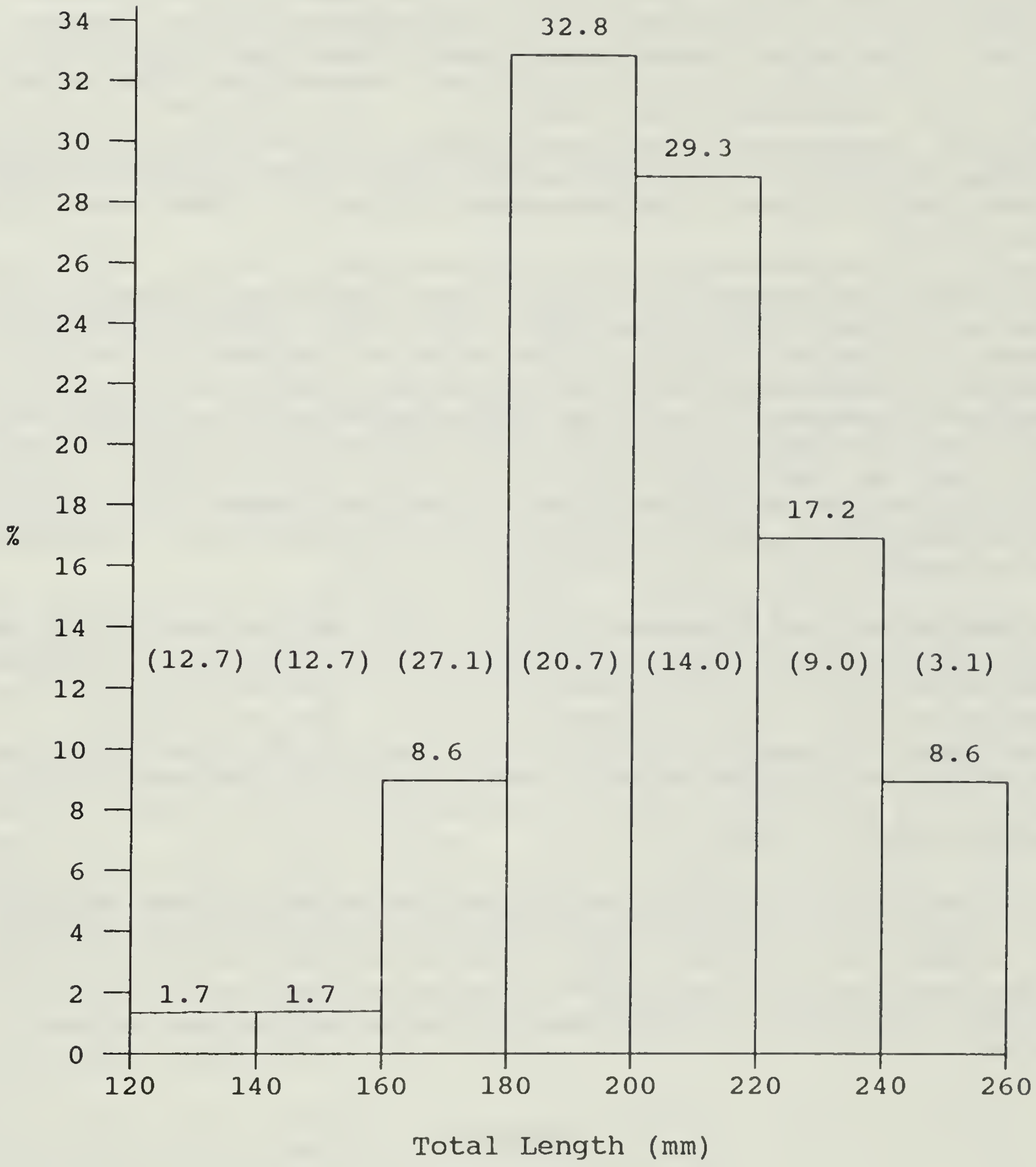

Figure 4. Length frequency distribution of the Ozark bass caught by fishermen from Buffalo River, Arkansas. Data based on creel census results collected in 1980 and 1981. The percentage that each size class was represented in the natural population is given in parentheses.

Ozark bass did not appear in the creel (Figure 4) until they reached 120 mm (about age 3) and did not begin to contribute significantly to the catch until they reached 180 mm (range, 130-255 mm). The catch rate for smallmouth bass observed in our study was generally higher than rates observed on other waters (Funk 1975, Paragamian and Coble 1975). Our observed catch rate for Ozark bass was slightly lower than the rate of 0.1 fish/hr reported for rock bass in the Little Miami River system in Ohio (Brown 1960); there is no comparable data for other Ozark bass populations.

Smallmouth bass taken from Buffalo National River appear to be older and larger than those taken from other "smallmouth bass streams". Fleener (1957), in his work on the heavily exploited Courtois Creek, found that 83% of the smallmouth bass caught were less than 5 years old. On the Buffalo River, 66% of the fish caught were younger than age V. In addition, fish of ages 1, 2, and 3 made up less than 20% of the catch on the Buffalo compared with 78% for the Red Cedar River, Iowa (Paragamian 1973), 62% for the Niagria River, Missouri (Funk and Fleener 1974), and 86% for the Maquoketa River, Iowa (Paragamian 1979).

The mean length of harvested fish was 280 mm for smallmouth bass from Buffalo River, compared with 262 mm in Red Cedar River, Iowa (Paragamian 1973), and 242 and 259 mm for two sections of the Maquoketa River, Iowa (Paragamian 1979). The percentage composition of smallmouth bass less than 230 mm long was lower in the creel than in the natural population, but smallmouth bass over 350 mm were about equally represented in the creel and in the population (Figure 3).

The proportion of creeled Ozark bass less than 180 mm was far lower than their proportion in the natural population. These data suggest that either anglers were selective in their harvest or that smaller fish were less vulnerable than larger ones to angling. They fail to indicate excessive harvest of either species.

SUMMARY

The data show no evidence that the increased fishing pressure on Buffalo National River has impacted smallmouth bass or Ozark bass. Ozark bass occupy habitats that are similar to those occupied by rock bass, a closely related species. Habitats occupied by smallmouth bass are similar to those reported to be occupied by the species in other Ozarkian streams.

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